

CLAIMS

1. A method of depositing material, preferably a film, on a substrate, comprising
5 the steps of:
providing a substrate;
heating the substrate;
generating an aerosol comprising droplets of a material solution;
providing a nozzle unit for delivering the aerosol to the substrate, the nozzle
10 unit including at least one outlet through which a directed flow of the aerosol is
delivered and at least one electrode;
charging the aerosol droplets with a positive or negative charge;
providing a flow of the aerosol through the nozzle unit so as to deliver a
directed flow of the aerosol from the at least one outlet; and
15 generating an electric field between the substrate and the at least one electrode
such that the directed aerosol flow is attracted towards the substrate.
2. The method of claim 1, wherein the substrate is heated to a temperature of less
than about 1050 °C, preferably less than about 800 °C.
- 20 3. The method of claim 1 or 2, wherein the substrate is heated during deposition.
4. The method of claim 3, wherein the thermal environment is such as to maintain
a decreasing temperature gradient in a direction away from the substrate
25 towards the nozzle unit.
5. The method of any of claims 1 to 4, wherein the material solution is an aqueous
solution.
- 30 6. The method of any of claims 1 to 4, wherein the material solution is a non-
aqueous solution.

7. The method of any of claims 1 to 6, wherein the aerosol droplets are at least partially charged prior to exiting the at least one outlet.
- 5 8. The method of claim 7, wherein the aerosol droplets are charged prior to exiting the at least one outlet.
9. The method of any of claims 1 to 7, wherein the aerosol droplets are at least partially charged after exiting the at least one outlet.
- 10 10. The method of any of claims 1 to 9, wherein the aerosol droplets are charged by the at least one electrode.
11. The method of any of claims 1 to 10, wherein the at least one electrode is disposed at least partially in each aerosol flow.
- 15 12. The method of any of claims 1 to 11, wherein the at least one electrode extends upstream of the at least one outlet.
- 20 13. The method of any of claims 1 to 12, wherein the at least one electrode comprises an elongate element.
14. The method of any of claims 1 to 13, wherein the distal end of the at least one electrode is located at substantially the centre of the at least one outlet.
- 25 15. The method of any of claims 1 to 14, wherein the distal end of the at least one electrode includes a single tip.
16. The method of any of claims 1 to 14, wherein the distal end of the at least one electrode includes a plurality of tips.
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17. The method of any of claims 1 to 16, wherein the nozzle unit includes a tubular section upstream of each outlet.
18. The method of claim 17, wherein the tubular section is an elongate section.
19. The method of claim 17 or 18, wherein the tubular section is a linear section.
20. The method of any of claims 17 to 19, wherein the tubular section is substantially cylindrical.
21. The method of any of claims 17 to 20, wherein the at least one electrode extends substantially entirely through the associated tubular section.
22. The method of any of claims 17 to 21, wherein the at least one electrode extends substantially along the central axis of the associated tubular section.
23. The method of any of claims 1 to 22, wherein at least the inner surface of the tubular section is composed of an insulating material.
24. The method of any of claims 1 to 23, wherein the aerosol flow is provided by entraining the aerosol in a flow of a carrier gas fed to the nozzle unit.
25. The method of any of claims 1 to 23, wherein the aerosol flow is provided by applying a reduced pressure to the at least one outlet so as to entrain the aerosol in a flow of a carrier gas drawn through the nozzle unit.
26. The method of claim 24 or 25, wherein the carrier gas is a gas reactive to the material solution.
27. The method of claim 24 or 25, wherein the carrier gas is a gas non-reactive to the material solution.

28. The method of any of claims 24 to 27 when appendant upon claim 4, wherein the flow of the carrier gas is provided such as to maintain the decreasing temperature gradient.
- 5 29. The method of any of claims 1 to 28, wherein the aerosol is delivered to the substrate such as to achieve a film growth rate of at least 0.2 μm per minute, preferably at least 1 μm per minute, more preferably at least 2 μm per minute.
- 10 30. The method of any of claims 1 to 29, wherein the flow rate through the at least one outlet is at least 5 ml per minute, preferably at least 50 ml per minute.
31. The method of any of claims 1 to 30, wherein the nozzle unit is configured such that the directed aerosol flow from the at least one outlet is directed upwards, preferably substantially vertically upwards.
- 15 32. The method of any of claims 1 to 31, wherein the nozzle unit includes a perforated member upstream of the at least one outlet.
- 20 33. The method of any of claims 1 to 32, wherein the applied voltage is less than about 35 kV, preferably less than about 20 kV.
34. The method of any of claims 1 to 33, wherein the distance between the at least one outlet and the substrate is less than about 100 mm, preferably less than about 50 mm.
- 25 35. The method of any of claims 1 to 34, wherein the substrate is held stationary relative to the nozzle unit.
- 30 36. The method of any of claims 1 to 34, further comprising the step of moving the nozzle unit relative to the substrate.

37. The method of claim 36, wherein the substrate is rotated, tilted and/or translated relative to the nozzle unit.
38. The method of any of claims 1 to 37, when performed at atmospheric pressure.
39. The method of any of claims 1 to 37, when performed below atmospheric pressure.
40. The method of any of claims 1 to 37, when performed above atmospheric pressure.
41. An apparatus for depositing material, preferably a film, on a substrate, comprising:
a substrate holder for holding a substrate;
a heater for heating the substrate;
an aerosol generator for generating an aerosol comprising droplets of a material solution;
a charge applicator for applying a positive or negative charge to the aerosol droplets;
a nozzle unit in communication with the aerosol generator for delivering the aerosol to the substrate, the nozzle unit including at least one outlet through which a directed flow of the aerosol is in use delivered and at least one electrode; and
a high voltage supply for generating an electric field between the substrate and the at least one electrode such that the directed aerosol flow is in use attracted towards the substrate.
42. The apparatus of claim 41, where configured to maintain a decreasing temperature gradient in a direction away from the substrate towards the nozzle unit.

43. The apparatus of claim 41 or 42, wherein the at least one electrode extends upstream of the at least one outlet.
44. The apparatus of any of claims 41 to 43, wherein the at least one electrode
5 comprises an elongate element.
45. The apparatus of any of claims 41 to 44, wherein the distal end of the at least one electrode is located at substantially the centre of the at least one outlet.
- 10 46. The apparatus of any of claims 41 to 45, wherein the distal end of the at least one electrode includes a single tip.
47. The apparatus of any of claims 41 to 45, wherein the distal end of the at least one electrode includes a plurality of tips.
- 15 48. The apparatus of any of claims 41 to 47, wherein the nozzle unit includes a tubular section upstream of each outlet.
49. The apparatus of claim 48, wherein the tubular section is an elongate section.
- 20 50. The apparatus of claim 48 or 49, wherein the tubular section is a linear section.
51. The apparatus of any of claims 48 to 50, wherein the tubular section is substantially cylindrical.
- 25 52. The apparatus of any of claims 48 to 51, wherein the at least one electrode extends substantially entirely through the associated tubular section.
53. The apparatus of any of claims 48 to 52, wherein the at least one electrode
30 extends substantially along the central axis of the associated tubular section.

54. The apparatus of any of claims 48 to 53, wherein at least the inner surface of the tubular section is composed of an insulating material.
55. The apparatus of any of claims 41 to 54, further comprising a gas supply unit in communication with the aerosol generator for supplying a flow of a carrier gas for entraining the aerosol and delivering the same through the nozzle unit.
56. The apparatus of any of claims 41 to 55, wherein the at least one outlet is directed upwards, preferably substantially vertically upwards.
57. The apparatus of any of claims 41 to 56, wherein the distance between the at least one outlet and the substrate is less than about 100 mm, preferably less than about 50 mm.
58. The apparatus of any of claims 41 to 57, wherein the nozzle unit and the substrate are held in fixed relation.
59. The apparatus of any of claims 41 to 57, wherein the nozzle unit and the substrate are configured so as to be movable relative to one another.
60. The apparatus of claim 59, wherein the substrate is rotatable, tiltable and/or translatable relative to the nozzle unit.
61. The apparatus of any of claims 41 to 60, further comprising a chamber for enclosing the substrate holder.
62. The apparatus of claim 61, further comprising a further gas supply unit in communication with the chamber for separately delivering a further gas to the same.
63. The apparatus of any of claims 41 to 62, wherein the nozzle unit includes a perforated member upstream of the at least one outlet.

64. A method of fabricating a powder, preferably an ultrafine powder, comprising the steps of:
- providing a heated zone;
- 5 generating an aerosol comprising droplets of a material solution;
- providing a nozzle unit for delivering the aerosol to the heated zone, the nozzle unit including at least one outlet through which a directed flow of the aerosol is delivered and at least one electrode;
- charging the aerosol droplets with a positive or negative charge;
- 10 providing a flow of the aerosol through the nozzle unit so as to deliver a directed flow of the aerosol from the at least one outlet; and
- generating an electric field between the heated zone and the at least one electrode such that the directed aerosol flow is attracted towards the heated zone where the aerosol droplets react homogeneously in the gas phase to form
- 15 a powder.
65. An apparatus for fabricating a powder, preferably an ultrafine powder, comprising:
- a heater for providing a heated zone;
- 20 an aerosol generator for generating an aerosol comprising droplets of a material solution;
- a charge applicator for applying a positive or negative charge to the aerosol droplets;
- a nozzle unit in communication with the aerosol generator for delivering the aerosol to the heated zone, the nozzle unit including at least one outlet through
- 25 which a directed flow of the aerosol is in use delivered and at least one electrode; and
- a high voltage supply for generating an electric field between the heated zone and the at least one electrode such that the directed aerosol flow is in use
- 30 attracted towards the heated zone where the aerosol droplets react homogeneously in the gas phase to form a powder.